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National Wildlife Research Center

Highlights Report, Fiscal Year 1996

U.S. Department of Agriculture

Animal and Plant Health Inspection Service
Animal Damage Control
National Wildlife Research Center
1201 Oakridge Drive
Fort Collins, CO 80525

Office of the Director (970) 223-1588, ext. 225
Information and Technology Transfer (970) 223-1588, ext. 239

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Issued July 1997

Contents

Introduction 4

National Wildlife Research Center, Fort Collins, CO 4

ADC Methods Development Research 5

Survey of Research Needs of the ADC Program 5

Research Highlights 6

Bird Research Projects 6

Mammal Research Projects 15

Product Development Research Projects 22

Program Support 28

Registration and Reregistration Status of APHIS/ADC

Pesticides and Drugs 28

Information and Technology Transfer 31

International Visitors 32

German Bird Strike Control 32

Chinese Scientist's Sabbatical at NWRC 32

Outreach Activities 33

Awards and Recognition 33

Meetings, Workshops, and Consultancies 34

Cooperation With Agencies and Universities 38

Science Education 40

NWRC Summer Interns 40

NWRC Tours 40

University of Nebraska Wildlife Students 40

Ohio State Wildlife Students 40

Elementary School Wildlife Presentations 41

Graduate Course on Advanced Wildlife Topics
at Washington State University 41

Publications 41

Introduction

National Wildlife Research Center, Fort Collins, CO

The Animal Damage Control (ADC) program is making progress in developing the new National Wildlife Research Center (NWRC) located on 43 acres of the Colorado State University (CSU) Foothills Research Campus in Fort Collins. An indoor Animal Research Building (ARB) was completed in 1995, the first building of a multistructure complex, and is now fully occupied. Construction work to add two large "simulated natural environment" animal research rooms, a tunnel washer, and an automatic animal-watering system to the ARB began in January 1997 and will be completed in the summer of 1997. All headquarters staff have been transferred from the Denver Wildlife Research Center (DWRC) in Lakewood, CO, to temporary space in Fort Collins.

Construction of a permanent NWRC laboratory/office/headquarters building, adjacent to the ARB, is expected to begin in the summer of 1997. The design of this building has been completed, and General Services Administration is soliciting interested private developers to build the structure. Eventually, all headquarters staff of NWRC will be located at one site on the CSU Foothills Campus. The design work for all other structures and outdoor animal research facilities at the 43-acre NWRC headquarters location has now been completed, and construction will proceed as funding becomes available.

Send correspondence to the Director's Office to the address given on the inside front cover of this brochure.

Currently, NWRC activities are split into different locations in Fort Collins. The following directory indicates principal activities and phone numbers.

1201 Oakridge Drive, 80525

(970) 223-1588

fax (970) 223-0776

Director's Office, administrative/program support unit (including personnel, facility coordination, fiscal, research library, information transfer, and archives and records), quality assurance unit, and registration liaison

1716 Heath Parkway, 80524

(970) 416-4500

fax (970) 416-4501

Bird research, mammal and product development research programs, and facility planning and development

308 N. Link Lane, 80524

(970) 472-9090

Storage Warehouse (no staff)

4101 Laporte Ave, 80521

(970) 491-3466

fax (970) 491-3583

Animal Care Unit and ARB

ADC Methods Development Research

In 1996, NWRC completed three initiatives to further improve its ADC research agenda and better address customer needs. First, the Center reorganized its existing research into 21 individual multidisciplinary projects of 3 to 5 years' duration. These projects have clearly stated goals and objectives, projected milestones, and expected outputs; each is subject to periodic reviews and annual progress updates. The titles, goals, and specific accomplishments of 19 of these projects are detailed in the Research Highlights section of this report. Second, NWRC realigned these research projects under three research program managers for bird, mammal, and product development research, and reassigned a number of individuals from support units into research units. Finally, NWRC completed a second national survey of ADC research needs, as described below.

Survey of Research Needs of the ADC Program

In 1989, the Animal and Plant Health Inspection Service (APHIS) and the ADC program conducted a survey of all ADC State Directors to assess the national research needs of the ADC program. This endeavor resulted in a list of research needs and their relative priorities, based on species and affected resource groups. The ADC program management team decided that an assessment of national research needs would be conducted about every 5 years. In 1991, ADC convened an expert panel of stakeholders in science, industry, agriculture, and the environment in Denver to identify research approaches to solve the wildlife damage problems identified in the 1989 survey. The 1989 survey and the 1991 expert panel still guide the ADC program's planning for methods development research. The research needs and approaches identified, along with congressional directives and input from the Deputy Administrator for ADC, have guided NWRC's allocation of resources to specific research projects that address the ADC program's priority research needs.

In February 1996, the ADC program's management team requested that the listing of ADC research needs and their relative priorities be updated. The objective was to determine the spectrum of wildlife damage problems faced by the ADC program and its customers that could be better addressed by additional scientific information, alternative control measures, or improvement in existing methods. The NWRC assistant director led a team consisting of an assistant director from each of the ADC Western and Eastern Regional Offices and the Director, ADC Operational Support Staff.

In April 1996, the ADC Deputy Administrator asked ADC State Directors and NWRC project leaders to identify their three most important research needs. By June, the NWRC Director had a list of 94 research needs. To obtain a shorter list that reflected relative priorities of the program, each team member, with input from his/her respective office, then identified the top three to five research needs within the areas of bird and mammal research.

Research Highlights

Criteria included (1) the rank order of needs as submitted by the ADC State Directors; (2) the extent of research effort over past years versus the need for future information, techniques, and solutions; (3) the availability of existing information and techniques that may simply need refinement versus the need for new techniques; (4) the value and magnitude of the resources affected as determined by Management Information System-generated data; (5) the ADC national, regional, or State importance; and (6) the perceived importance to customers.

Table 1 lists the top three to five specific research needs (in no particular order) in the areas of bird and mammal research. The principal research needs identified in the 1996 survey were related to understanding and finding solutions to resolve (1) blackbird roosting and agriculture problems, (2) urban and suburban problems caused by waterfowl or gulls, (3) piscivorous bird damage to aquaculture, (4) predator damage to livestock, and (5) small-mammal damage in a variety of agriculture situations. In addition, the 1996 survey made clear that the ADC program needs to improve understanding of the economics of damage caused by a variety of species, to develop products for species in various situations, to identify possible wildlife involvement in human or animal diseases and develop methods and strategies for reducing their transmission, to assure a swift response capability by NWRC to new, emerging research issues, and to improve information dissemination.

The bird and mammal research needs identified in table 1 are considered to be the highest priority needs of the ADC program and also reflect the needs of many of ADC's customers. These priority research needs, in addition to congressional and other directives, guide the NWRC Director in implementing new research projects as current projects are completed, specific objectives within current projects are achieved, and additional resources become available. Boldface type indicates research currently being addressed in ongoing methods and development projects.

Bird Research Projects

Title: Development of management strategies to reduce piscivorous bird predation at aquaculture facilities

Goal: Determine the magnitude of, and develop methodology to reduce, bird predation on cultured aquaculture products, including catfish, baitfish, tropical fish, trout, and other finfishes.

Impact of Piscivorous Birds on the Northeastern Aquaculture Industry—NWRC biologists at

Starkville, MS, in cooperation with ADC State programs in New Jersey, Pennsylvania, and New York, evaluated the impact of piscivorous birds on commercial aquaculture facilities in the Northeastern United States. Biologists interviewed 61 facility managers, took a census of birds frequenting aquaculture facilities, conducted behavioral observations, analyzed stomach contents, and quantified fish production at netted and unnetted raceways to determine the species causing damage and determine the extent of losses.

Almost three quarters of the facilities surveyed raised trout, with the remainder raising a variety of warm-water fish. Of the managers surveyed, 80 percent considered piscivorous birds to be a problem at their facilities, with 75 percent of those farmers indicating great blue herons to be the main depredating species. Northern mallards, common grackles, and belted kingfishers also caused problems. Although economic losses varied widely among farms, at the highest densities observed, herons removed an estimated \$500 worth of fish per day.

Results of exclusion trials analyzed from three aquaculture facilities provided further evidence of the economic impact of great blue herons. Fish inventoried in pools without exclusion netting numbered 9 to 45 percent fewer than fish in pools with exclusion netting, with estimated losses over a 3- to 4-month period of \$464 to \$5,133 per unnetted pool. With more than 10 pools of fish vulnerable to predation at each facility, the total economic loss at each facility

Table 1—Highest priority research needs of the ADC program, 1996

BIRDS

- **Determine the economic impact of, and investigate and develop methods to protect freshwater and marine aquaculture resources from bird damage, in the Southeastern and Northeastern United States.**

Specific needs identified related to understanding **local and migratory movements, impacts, and control methods (lethal and nonlethal, contraceptives) for cormorants to consumable fish**, and other piscivorous birds to the baitfish, **tropical fish**, and crawfish industries.

- **Reduce the negative impacts of waterfowl (geese, ducks, mute swans) in agriculture, fishery, and human health/safety (water quality) in urban/suburban situations.**

Specific needs identified related to developing new management methods, including oral contraceptives, **hazing and harassment techniques**, and barriers to impede waterfowl movement at water's edge; evaluating shooting as a reinforcement to harassment; and differentiating between migratory and nonmigratory waterfowl populations.

- Determine the causes of vulture predation on birthing and young livestock and damage to plastics, vinyl, rubber, vehicles, and structures on outdoor property and develop effective methods and strategies to resolve these problems.

- **Investigate and develop methods needed to manage problem blackbird or starling roosts in urban, suburban, and industrial situations.**

Specific needs identified related to developing **lethal chemicals, nonlethal aerosol repellants, contraceptives**, and other roost control or dispersal methods.

- **Develop more methods to protect crops from bird damage.**

Specific needs related to identifying or developing and making available lethal and nonlethal (repellants) chemicals to reduce blackbird damage to sorghum, **sprouting** and mature corn, **sunflowers**, **seeded** and headed rice; to reduce sandhill crane damage to corn; and to reduce **bird damage to berry crops**.

- **Develop more tools/techniques and strategies for managing gull populations in agriculture, fishery, and human health and safety situations.**

Specific needs identified related to **obtaining information** on the social, economic, and **biologic impact of gulls to landfills**, structures, other wildlife, and water quality, and **identifying effective control methods**.

- Develop methods to estimate the numbers of birds killed during operational use of chemical control methods.

MAMMALS

- **Assess strategies and programs and develop methods to manage coyote predation on livestock.**

Specific needs related to (1) assessing the effectiveness of preventive control to reduce coyote predation on sheep and lambs; (2) documenting sheep losses to coyotes in areas with and without operational control; (3) identifying and developing methods to census coyote populations; and (4) **identifying and investigating the effectiveness of nonlethal methods (repellants, guard dogs, llamas, the electronic guard), humane and efficient capture methods, and reproductive inhibition techniques for predator management**.

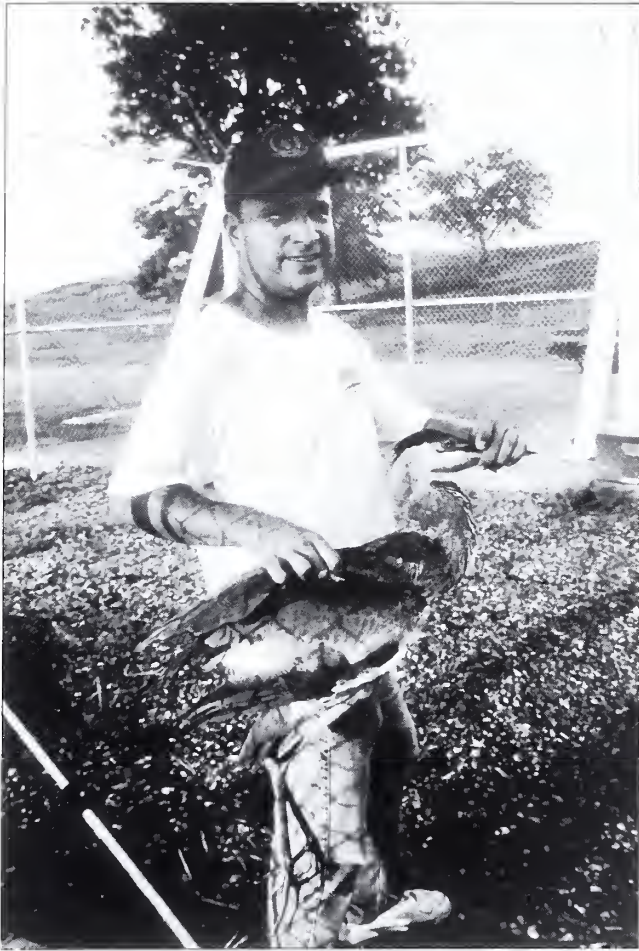
- **Develop methods and programs to protect forest, orchard, and nursery resources from damage by ungulates.**

Specific needs relate to developing safe, efficient, and economical methods (repellants) to **reduce the impacts of deer**.

- **Develop methods (repellants, lures) to manage beaver populations in urban/suburban situations.**

- Determine the costs and benefits of oral rabies vaccination programs.

- **Investigate a wider variety of methods (rodenticides, repellants, immunocontraception, habitat management) and programs to protect agricultural crops, forestry, and rangelands from damage by rodents.**



would be an order of magnitude greater. Further analysis of the data from these trials will provide aquaculture managers with data on the impact of piscivorous birds as a means to evaluate the cost effectiveness of possible control measures.

Wading Bird Predation on Catfish—NWRC researchers at Starkville, MS, determined several years ago that cormorants in the delta region of Mississippi were responsible for most of the depredation on farmed catfish there. Investigators also discovered that dispersal of cormorants from winter roosts in the region would significantly reduce cormorant damage to catfish. This information was transferred to Mississippi's ADC Operations personnel, who developed a delta-wide roost dispersing operation. The dispersing operation has now been

undertaken by the catfish producers to make the effort more effective. ADC operations and research staff will continue to assist, monitor, and evaluate the dispersal program. This effort exemplifies the close working relationship of ADC research and operational staff and the producers in Mississippi.

Impact of Pelicans on the Southeastern Aquaculture Industry—American white pelicans that spend the winter in the Southeastern United States have become an increasing problem at commercial aquaculture farms. One pelican can eat 1 to 3 pounds of fish per day, and as many as 1,000 pelicans sometimes feed in a single pond. Since 1993, hoping to improve understanding of the impact of pelicans on the southeastern aquaculture industry, NWRC biologists have been conducting an aerial censusing program to determine the winter population of pelicans in the Mississippi delta region. From November 1995 through June 1996, the average number of pelicans observed per census was 1,477 from November through January, 4,603 from February through March, 1,403 in April, and 203 in June. The higher pelican numbers in the February–March period coincided with peak spring migration; the lower numbers during the other months coincided with pre- and postmigration periods, as well as with dry conditions and the resulting limited availability of flooded fields in which pelicans can loaf.

A multiyear radiotelemetry study of American white pelicans is also being conducted in hopes of better defining regional movements and activity patterns. Of 19 pelicans captured and fitted with radio transmitters during the winter of 1994–95, 14 were located in the Mississippi delta region or south Louisiana during the winter of 1995–96. Preliminary indications are that pelican activities vary depending on the type of loafing site. Pelicans that loaf on mud bars and flats and forage in the Mississippi River and large lakes tend to spend more time foraging than pelicans that loaf in flooded fields and forage in catfish ponds.

Bird Predation in Tropical Fish—In Florida, the snowy egret (*Egretta thula*) and green-backed heron (*Butorides virescens*) are the two most abundant species involved in predation. Problem species also include hooded mergansers (*Lophodytes cucullatus*) and belted kingfishers (*Ceryle alcyon*). The economic impact of birds on tropical fish productions is just starting to be quantified, but initial findings have suggested that pond yields are being reduced 30 to 35 percent, at a value of \$240 to \$1,200 per pond. With 180 commercial fish operations and sales of \$47 million in 1993, tropical fish is the most important economic component of Florida's \$73 million aquaculture industry.

Several factors may contribute to the conflict between birds and tropical fish production in Florida. The tropical fish industry is based east of Tampa Bay, within 40 miles of large breeding and wintering wading-bird colonies. Tropical fish are grown in relatively small outdoor ponds (about 8 × 25 m) on farms averaging about 5 ha. Ponds are stocked at densities as high as 20,000 fish/pond. Assuming a conservative value of \$0.15/fish, one small pond can hold a crop valued at \$3,000.

Title: Management strategies to control black-bird damage in the United States

Goal: Reduce the magnitude of health, safety, and nuisance problems caused by blackbirds and improve agricultural production by reducing blackbird depredation losses in citrus- and fruit-producing enterprises and on sprouting and ripening corn, sunflower, rice, and other grains.

Reducing Blackbird Damage to Sunflower Crops in the Northern Great Plains

—In Minnesota and the Dakotas, millions of common grackles, red-winged blackbirds, and yellow-headed blackbirds begin congregating in dense cattail marshes in midsummer and start feeding on early ripening sunflower crops. Annual sunflower losses to blackbirds amount to millions of dollars. Chemical repellants, mechanical scaring devices, avicides, and altered cultural practices have been tested to reduce these losses. Each method has limitations due to cost, logistics, effectiveness, or adverse environmental effects. New management techniques are needed for reducing blackbird damage to sunflower crops.

Research on the use of DRC-1339-treated rice baits placed in ripening sunflower fields was completed in 1996. An analysis of sunflower damage data revealed that DRC-1339-treated rice baits failed to protect ripening sunflower. The poor efficacy of the baits was due, in part, to the constant migration of many new birds into the study area, movement of blackbirds among roosts, and movement of birds among sunflower fields, which hampered accurate predictions of preferred feeding locations.

A 3-year study to assess the feasibility and potential nontarget hazards of using DRC-1339-treated rice baits to reduce spring migrating populations of blackbirds was initiated in 1996. A substantial reduction of prebreeding blackbird numbers may reduce the postbreeding population, and that, in turn, may reduce sunflower damage.

Preliminary results suggest that thousands of blackbirds can be easily attracted to 2-acre plots treated with 1339/rice baits with minimal nontarget impacts.

Title: Management of wildlife that pose hazards to aviation

Goal: Develop safe and effective methods for reducing wildlife hazards to the air transport industry.

Experimental Shooting Program Reduces the Number of Aircraft Strikes at Kennedy Airport—

The collision of birds with aircraft is a serious problem at John F. Kennedy International Airport (JFKIA) in New York. Laughing gulls accounted for 52 percent of the bird strikes between 1988 and 1990, averaging 157 bird strikes per year. This species is present from May through September in association with a 7,600-bird nesting colony in Jamaica Bay adjacent to the airport.

An experimental program to reduce gull collisions with aircraft there was undertaken during the months of May through August in 1991 through 1996. Two to five ADC biologists were stationed on airport boundaries from May 20 through August 15 each year and used shotguns to reduce gulls flying over the airport. In 5,636 person-hours of firing, about 48,000 gulls were eliminated. No nontarget species were affected, and no nontarget gulls (i.e., gulls not on the airport) were killed.

The gull shooting program had a dramatic effect on bird–aircraft strikes. The number of aircraft strikes by laughing gulls declined by 66 percent during the shooting period in 1991 and by 76 to 89 percent during the shooting period in 1992–96, in comparison with the mean of 136 strikes during May 20–August 15 in 1988–90. Strikes by the other gull species were reduced by a comparable amount.

In spite of the removal of laughing gulls between 1991 and 1996 (about 2.9 times the number of adult gulls in the Jamaica Bay nesting colony in 1990), the nesting colony declined by only 38 percent between 1990 and 1996. In addition, data from the North American Breeding Bird Survey indicate that the laughing gull population along the Atlantic coast has remained stable since 1991. Thus, although shooting is an effective means of reducing the incidence of aircraft strikes by birds, the shooting program has not caused a major decline in the nearby nesting colony nor the U.S. gull population.

ADC's recommended long-term solution is to relocate the nesting colony away from JFKIA. A seasonal shooting program, coupled with other management programs to deter gulls from the airport, should continue to minimize the number of gull–aircraft collisions until this relocation is achieved.

Use of Lime as a Safe and Inexpensive Feeding Repellent for Birds and Mammals—

Increasing concern about Canada geese and blackbird depredations in agricultural crops and general nuisance in urban areas has led to public demand for environmentally safe, nonlethal avian feeding repellants. NWRC scientists at the Sandusky, OH, field station discovered in 1994 that lime-based powders (e.g., dry portland cement, plaster-of-paris) were strongly repellent to red-winged blackbirds in aviary feeding tests. Because lime is safe, inexpensive and already used as an agricultural soil treatment, NWRC biologists further tested lime as a bird and mammal feeding repellent. Aviary trials with brown-headed cowbirds demonstrated repellancy comparable to that seen with red-winged blackbirds: greater than 94-percent reduction in feeding on lime-treated millet in the presence of untreated millet and a 39-percent reduction in the absence of alternative food.

Promising results were also obtained using lime as a goose feeding repellent on turf in enclosures. Foraging by Canada geese was reduced 90 percent for 3 days using an application rate of 544 kg/ha (484 lb/acre). Rainfall after day 3 of the trial removed lime from the grass and reduced its effectiveness.



Title: Development of nonlethal chemical repellants for birds

Goals: Develop methodologies that contribute toward the discovery and practical development of nonlethal, environmentally benign chemical repellants for use in resolving conflicts between wildlife and agriculture and industry.

Effect of Method of Repellent Preparation on

Activity—Recent studies have indicated that lime is effective as a goose-grazing repellent, but followup studies using lime as a seed coating to protect rice from blackbird depredations have yielded poor results. Questions remain about whether these variable results reflect crop and/or species differences.

Biologists also compared the effectiveness of lime and three other particulate materials as deer feeding repellants when applied to corn at established deer feeding stations. All particulates were mixed 4 percent w/w with whole-kernel corn. In comparison with untreated corn, consumption of treated corn declined. The reduction in consumption was greatest with corn treated with lime (87 percent), followed by corn treated with charcoal (71 percent), Nutra-Lite™ (50 percent), and sand (22 percent).

Lime as a feeding repellent for birds and mammals may have wide application because of its low cost, ready availability, and ease of registration. Additional studies are planned to determine the repellent mode of action and minimum effective concentrations of lime for birds and mammals and to develop formulations that will better adhere to vegetation.

Laboratory studies have shown that the method of applying lime to a crop will drastically influence lime's effectiveness as a repellent. When lime is adhered to millet in particulate form, cowbirds avoid the treated grain. The findings from these studies are consistent with previous studies that show particles attached to grains, feed, or turf can act as effective bird repellants.

When the particle size coating is greatly reduced, by mixing the lime and millet as a slurry, cowbirds consume treated and control millet in similar quantities. Under this preparation, the lime adheres to the millet as a fine dust. These findings are consistent with those of previous studies that have found that ultra fine particles do not detract from the palatability of food.

When filtered lime solutions are used to treat millet, cowbirds tend to prefer the treated millet. Because the pH of the treated millet is similar in all treatments, it appears that repellancy is due to particle coatings of the seed.

Effects of Carriers and Stickers on Repellancy—

Field studies often fail to demonstrate efficacy of formulated bird repellants, despite theoretically sufficient quantities of repellant deposited on crops. Failure of the active ingredients to perform up to expectation can be attributed to a variety of causes. Formulations may in some way interact with the active ingredient to neutralize its effect or fail to protect the active ingredient under environmental conditions. The formulated repellant may also be inappropriately applied in the field or may not be sufficiently aversive under prevailing ecological and social conditions of the target species.

Laboratory studies have shown that the bird repellant methyl anthranilate (MA) can interact with a variety of carriers. Graphite, charcoal, and wax carriers will bind the MA and make the repellant unavailable to the receptors that mediate repellancy in birds. Because graphite is a commonly used matrix for granular pesticides, adding MA to deter birds from consuming the pesticide will not have the desired effect.

Similarly, stickers and other agricultural adjuvants are used to hold MA and extend the period of protection offered by the repellant to turf, berries or other crops susceptible to bird depredation. Laboratory studies have shown that as much as 60 to 90 percent of the MA on cherries is tightly held by various agricultural stickers, and may not be available as a repellant. These findings are consistent with observations that indicate poor performance of MA when it is applied to berry crops in the field.

In turf studies, where MA content was monitored during the course of field evaluations, repellancy of the formulated products was good when MA content was above 550 p/m. Failure to maintain this level of MA was normally associated with hot and humid conditions. The longest periods of efficacy were obtained under cool, dry conditions. Laboratory studies indicate that microbial degradation is the principal concern in maintaining sufficient concentrations of MA in turf applications.

MA can be an effective, safe bird repellant, but care must be taken to use an appropriate formulation and application strategy. Continued efforts to identify the best carriers that protect the compound from degradation without adversely affecting the ability to release the compound to depredating birds remain the largest challenge in realizing the potential of this nonlethal repellant.

Title: Management strategies to reduce bird problems in the Western United States

Goal: Develop safe and effective methods to reduce bird problems in the Western United States.

Reducing the Risk of Waterfowl to White

Phosphorus—The U.S. Army has used Eagle River Flats, a 1,000-ha salt marsh at Fort Richardson, AK, since 1945 as an artillery impact area. During the past 10 years, waterfowl have been found dead on the flats during spring and fall migration. Their mortality has been attributed to the ingestion of white phosphorus residue in marsh sediment. To remediate this situation, the Army is considering dredging or covering sediment that has been contaminated with white phosphorus. NWRC scientists continue to evaluate a promising product known as AquaBlok™—a blend of calcium bentonite and organo clays, gravel, and polymers—that binds to itself and to sediment to form a sealant.

In 1994, a 0.5-ha contaminated pond was covered with 142,000 kg of AquaBlok to a depth of about 7 cm. Application was made by Army helicopters. Since that time, there has been no observed waterfowl mortality on the site. In 1996, visual inspection of the site indicated that plants are well established in sediment that has been deposited on top of the AquaBlok by tidal action. Core samples indicated that the AquaBlok is still intact and is covered with several millimeters of sediment.



Movements of Bald Eagles Exposed to White Phosphorus at Eagle River Flats—Since the early 1980's, the number of bald eagles at the Eagle River Flats has been increasing during the spring migration period. Biologists have concluded that eagles are responding to the waterfowl mortality occurring on the Flats. Beginning in the spring of 1994, eagles were fitted with standard or satellite transmitters. To date, 24 eagles have been captured on the Flats. Of these, 11 were fitted with satellite transmitters that will continue to be monitored until 1997. Three eagles are currently nesting and raising young on Eagle River Flats. These eagles have been observed several times scavenging dead ducks from the Flats without subsequent mortality. In addition, no mortality has been detected among eaglets.

Ring-Billed Gull Impact on Migrating Salmon Smolt—The Columbia River once was known for having the world's largest runs of anadromous salmon. Several problems, which include gull predation on salmon smolt, have severely reduced these runs. In 1995, NWRC biologists, in cooperation with Washington State ADC personnel, began a 3-year study to determine the impact of ring-billed gulls on Columbia River salmon smolt. The study was designed to determine food preference of ring-billed gulls at the Priest Rapids dam during salmon smolt migration, along with the movement and distribution of ring-billed gulls from a breeding colony. Researchers compared the effects of white mineral oil and corn oil on hatchability of ring-billed gulls to determine what the effects of treating eggs in the colony had on gull behavior and colony size.



In 1996, more than 9,000 ring-billed gull eggs from 3,541 nests within the nesting colony were again treated with corn oil. Hatching success was less than 0.5 percent. The number of breeding pairs of ring-billed gulls increased 11 percent from 1995. Indications are that gulls are dispersing to other colonies and gull production on the island has been reduced completely. However, the number of nests on the island has increased. At this point, it is too early to determine whether continued egg oiling will eventually cause abandonment at the colony. Gulls continue to forage at the face of Priest Rapids dam. Ring-billed gulls collected from this area contained almost exclusively salmon smolt, ranging from 1 to 4 fish/gull.

Potential Horned Lark Repellants for Sprouting Lettuce Seedlings

Horned lark damage to lettuce is a severe problem in several areas of California and Arizona. Millions of dollars worth of lettuce seed and seedlings are believed to be lost annually. In 1996, NWRC biologists evaluated five chemical compounds—MA, Mesurol™, charcoal, lime, and fipronil—as potential repellants to treat lettuce seeds and seedlings. Aviary experiments were conducted to determine the effectiveness of each chemical compound as an overspray on sprouting lettuce seedlings.

In each experiment, horned larks were offered a preferred food mix and a flat containing from 80 to 123 3-day-old lettuce sprouts. After a 3-day pretreatment period, flats of lettuce sprouts were sprayed with MA (8 kg/ha), Mesurol (4 kg/ha), activated charcoal (32 kg/ha), lime (932 kg/ha), or fipronil (94 kg/ha). During a 3-day posttreatment period, MA and Mesurol significantly reduce horned lark consumption of lettuce sprouts. In addition, none of the chemical compounds resulted in any adverse effects on sprout vigor.

North Island Naval Air Station Bird Research—

Working in cooperation with the U.S. Navy at North Island Naval Air Station in San Diego Bay, NWRC scientists are conducting a study to determine the movements of western gulls in relation to potential aircraft—gull hazards on the air station. Gulls numbering in the hundreds roost nightly on the runways. Of the more than 600 gulls, 12 have been captured and marked with colored patagial tags and have had satellite transmitters attached. A review of the literature suggests that most gull activity occurs within 30 miles of land. However, satellite data received so far indicate substantial long-distance movements by the birds being tracked. During a 6-week period, one radio-equipped gull moved about 500 miles up the west coast of California from San Diego to Santa Cruz on Monterey Bay, and at least two gulls have traveled as far as 120 miles off the California coast, farther than any formerly documented offshore movements. Analysis of the data to date indicates widespread movement and fairly high population turnover of birds on the North Island Naval Air Station.

Mammal Research Projects

Title: Development and evaluation of new techniques for resolving predator depredation problems

Goal: Develop new or improved control technology systems for operational use in predator management.

Standard and Modified Padded-Jaw Traps To Reduce Coyote Leg Injuries—The foothold trap is an important tool for resolving many damage and depredation problems caused by coyotes; however, opposition to the use of traps has increased in recent years because of concern by interest groups that traps inflict unacceptable injuries on trapped animals and are therefore inhumane. NWRC scientists, in cooperation with ADC field personnel, recently evaluated injuries associated with using modified No. 3 Victor Soft Catch™ traps. Standard Soft Catch traps were modified with the addition of a "Taos lightning" spring kit. The additional springs allowed each trap lever to be powered by two coil springs instead of one.

California ADC specialists captured 113 coyotes during the course of the employees' regular duties. Legs from the animals were necropsied by a veterinary pathologist from the University of Wyoming. Individual injuries were assigned scores based on a trauma scale developed through the international standards process. Pain, loss of function, wound severity, healing potential, and releasability of the animals were considered in establishing point values.

Modified padded traps generally produced lower injury scores than the standard Soft Catch trap and much lower scores than all the previously tested unpadded traps. Minor injuries, such as small cuts and edema, were noted on many of the coyote legs. Also, the capture rate with the modified traps was similar to the capture rates with other coyote traps that have been tested.

Title: Management of livestock depredation in California: developing more selective control strategies

Goal: Develop effective and environmentally responsible strategies for reducing livestock depredation through selective targeting of predators.

Selective Coyote Predation Control in North Coastal California—Coyote control can be made more effective and environmentally sound if the specific coyotes killing sheep (particularly at the onset of the annual depredation peak) can be selectively removed. The behavioral ecology of coyotes, together with depredation patterns and animal removal strategies, have been studied since 1993 at the University of California's Hopland Research and Extension Center, a 5,600-acre sheep research facility in north coastal California. Coyote depredation has been a serious and chronic problem that has forced many small producers in this coastal area out of business. A cooperative project involving NWRC, the University of California at Berkeley, and the Hopland Center has examined several aspects of the problem.

At the Hopland Center, radiotelemetry studies showed that not all coyotes using the area killed sheep. Those that did were characterized as territorial, breeding adults whose territories overlapped active sheep pastures. During the 1994 and 1995 lambing seasons, a single pair of territorial coyotes was responsible for 108 (79 percent) of 137 confirmed kills by coyote. Adult territorial coyotes proved difficult to remove by standard control methods; M-44's were significantly more effective in removing juvenile and yearling coyotes, relative to the proportion of each age group captured by traps or snares. Successful removal of territorial, breeding pairs of adult coyotes reduced subsequent predation on sheep, but these pairs had been replaced by new coyotes by the next lambing season. Coyotes killing sheep were found to be the adult breeders whose territories overlap sheep pastures, particularly those

with lambs. Such coyotes have been especially difficult to remove during the lambing season (January–April) prior to whelping and the pup-rearing season (April–September).

Results to date indicate that strategies and methods of coyote predation control need to be appropriate for selecting territorial breeding coyotes, particularly during the lambing season, which in north coastal California usually precedes coyote pup-rearing.

Title: Sensory and behavioral methods for managing predation on livestock

Goal: Identify chemical repellants and deterrent methods and create attractive baits for target-specific delivery of pharmaceutical substances to reduce livestock depredation.

Analysis of Taste and Olfaction in Selected Wildlife Species—NWRC scientists at the Monell Chemical Senses Center in Philadelphia, PA, continue to test materials and develop strategies to manage mammals and birds. Recent electrophysiological studies have demonstrated that effective mammalian repellants are typically irritants that stimulate pain receptors. This result is consistent with the observation that the avoidance of repellent chemicals is immediate and occurs in the absence of ingestion. The finding that repellants stimulate measurable electrical activity in pain receptors is important because it suggests that in-vitro methods might be used to examine the activity of these cells in the presence of candidate irritants. Cell-culture experiments, if successful, would reduce the number of animals used in research and enhance the economy of screening procedures for repellants.

Ongoing evaluation of natural products' efficacy has been broadened to include a variety of substances that can be commercialized without registration with the U.S. Environmental Protection Agency (EPA). One such substance is garlic, a material that is substantially repellent to a variety of rodents. Garlic extract (and other sulfur compounds) also repels

birds, so there is a possibility that garlic might be useful in a spectrum of applications.

Coyote Taste and Color Stimuli—Experiments have been initiated to examine the responsiveness of coyotes to a variety of taste and color stimuli. Coyotes were presented with sweet, salty, sour, bitter, and protein tastes in one-choice 6-hour drinking tests. Fructose and glucose were highly preferred by both males and females, regardless of season. Quinine hydrochloride was strongly rejected. No other tastes elicited reliable differential responding. These results suggest that disaccharide sugars may be useful additives to baits. This result is especially interesting because obligate carnivores such as red foxes and felids are typically indifferent to sugars, and most avian species are either indifferent to or reject these substances. Accordingly, the possibility exists that sugar-based baits may be relatively species selective.

Because the effectiveness of chemical lures is dependent on a variety of ambient environmental conditions (e.g., wind, temperature), researchers are investigating the possibility that color can be used to enhance bait detection and examination.

Recent investigations have evaluated the importance of contrast effects (i.e., the degree to which lure color contrasts with background color). When coyotes were presented with novel black, white, or brown dowels in large outdoor enclosures, white dowels were detected at the greatest distance and sustained greater damage than either black or brown dowels. This finding suggests that in unfamiliar environments, novel color cues that contrast with background colors may be useful for bait detection and investigation by coyotes.

Title: Reproductive intervention strategies for managing predation

Goal: Determine whether sheep losses to predation can be reduced by sterilizing coyotes on territories where sheep and other livestock are pastured and transfer information critical to the registration and/or practical application of sterilant technologies and pharmaceutical products.

Coyote Reproductive Studies—Available evidence suggests that coyotes are less likely to kill livestock in the absence of pups than in their presence. This observation suggests that chemical or immunological sterilization or other technologies that reduce fecundity may have utility as coyote depredation control strategies. To test this possibility, Utah field station personnel, in collaboration with NWRC scientists and specialists at the University of Wyoming, are proceeding with a variety of experiments to evaluate several methods of sterilization and fecundity reduction, as well as pinpoint any behavioral changes that accompany changes in fecundity.

To date, researchers have assessed the effectiveness of porcine zona pellucida (PZP) and gonadotrophin-releasing hormone on reproduction, territorial maintenance, and pair-bonding in coyotes. Both treatments reduced fecundity but did not eliminate reproduction (i.e., fewer pups were born to treated pairs than to control pairs). Territorial maintenance and pair-bonding behaviors of treated coyotes were not affected.

Title: Development of methods to reduce wildlife damage to agricultural and forest resources

Goal: Develop, test, and implement methods to reduce wildlife damage to crops and property.

Physical Barriers To Reduce Pocket Gopher Damage to Seedlings—Pocket gophers can significantly undermine reforestation efforts and cause substantial losses to agricultural crops, such as alfalfa. Gophers live underground in closed burrow systems and, by their feeding activities, damage or kill plants both above and below ground. Historically, gopher populations and the damage they cause have been reduced by the use of toxicants or kill traps placed within burrows. Recent research efforts have sought nonlethal methods to reduce gopher damage.

NWRC scientists at the Pullman, WA, field station conducted field trials with physical barriers—sandpaper and plastic tubes—in an effort to protect seedlings from gopher damage in two national forests in Oregon. Both types of tubes were placed around seedlings at the time of planting to cover the plants both above and below ground. Although the tubes somewhat reduced damage levels, after 2 years the amount of damage for the tubed seedlings was not significantly less than for the untubed (control) seedlings. Gophers could damage seedlings by chewing through the tubes or by attacking parts of the seedlings protruding above or below the tubes. Additionally, the sandpaper tubes tended to constrict around the seedlings and promote heat buildup, causing high levels of mortality. Because of the cost of installing and maintaining the tubes and their lack of effectiveness, future trials of such barriers are not currently planned.

Title: Reducing bear damage to agricultural resources

Goal: Provide feasible and effective methods for reducing bear damage to agricultural resources.

Bear Damage to Forest Resources, Forest Management Practices, and Chemical Constituents Within Trees

—The extent of damage inflicted on trees by black-bear foraging is correlated with chemical and physical variables of trees. Increased carbohydrate concentrations and increased vascular tissue mass are correlated with increased bark removal by bears. Increased terpenoid concentrations are correlated with decreased bark removal. NWRC scientists have inferred that foraging animals use these variables in deciding which trees to eat. The observation that some forest plantations do not sustain damage while other plantations are heavily damaged may reflect the fact that bears are maximizing carbohydrate intake and/or minimizing terpenoid intake.

To determine whether changes in carbohydrate and terpenoid concentrations in forage material change black-bear preferences, a foraging preference study was conducted in the field. Four test diets with a base formulation similar to the food pellets used in the Washington Forest Protection Association Supplemental Feeding Program were produced and offered to free-ranging black bears. The test diets consisted of pellets with (1) high carbohydrate and high terpenoid content, (2) low carbohydrate and high terpenoid content, (3) high carbohydrate and low terpenoid content, and (4) low carbohydrate and low terpenoid content. The compounds were added to the pellets in concentrations mimicking the chemical content of Douglas-fir vascular tissue normally encountered by foraging black bears.

The results of this study clearly demonstrated that both carbohydrate and terpenoid content play active roles in foraging preference. Free-ranging bears preferred diets high in carbohydrates over those low

in carbohydrates. Concurrently, increased terpenoid content reduced intake of the diet high in carbohydrates.

The impact of common silvicultural practices on the distribution of carbohydrates and terpenoids in vascular tissue is currently being studied. Through working jointly with the Stand Management Cooperative, the effects of thinning and fertilization, as well as the interaction of these treatments, are being investigated as to how they relate to the concentrations of carbohydrates and terpenoids in Douglas-fir vascular tissue. Samples have been collected on nine of the Cooperative's installations in Washington and Oregon. Additionally, the effects of pruning are being investigated at three Oregon Department of Forestry research sites.

Title: Reducing beaver damage to agricultural resources (Olympia, WA, and Fort Collins, CO)

Goal: Develop feasible and effective methods for reducing bear damage to agricultural resources.

Effects of Textural Repellants in Reducing Beaver Damage to Trees

—Painting tree trunks, stems, and structural components (e.g., boards) that are susceptible to beaver damage with textural repellants may inhibit damage by beaver. The extent to which tree segments were gnawed by beavers in controlled pen trials was significantly reduced when the stems were painted with textural repellants. The textural repellant evaluated in the study was a simple mixture of sand and alkyl paint. Untreated stems or stems treated with paint containing no sand were severely damaged during the 2-week trial, whereas stems treated with a mixture of paint and sand sustained only minor damage. In fact, 8 of 10 beavers completely avoided stems painted with the mixture of paint and sand, and the 2 beavers that did not avoid these stems damaged them only slightly. Sandpaper sheets can provide similar protection. Repeated destruction of beaver holding pens stopped when the frames and

sides were covered with sandpaper. Textural repellants will be field-tested in a number of beaver-damage situations in 1997.

Title: Reducing mammal damage to forest resources

Goal: Develop feasible and effective methods for reducing wildlife damage to forest resources.

Monitoring Hazards to Nontarget Species of Strychnine Baiting To Reduce Pocket Gopher Populations—Efforts to replace trees damaged by fire or harvested for timber are often futile in areas with large populations of pocket gophers. Strychnine baiting is one method used to reduce the gopher populations prior to planting seedlings. Bait is applied underground in active burrow systems to maximize treatment efficacy and to minimize negative impacts on nontarget species; however, there remain concerns that operational baiting of pocket gophers may adversely affect nontarget species.

NWRC scientists implemented an intensive capture and release program. To monitor the occurrence of nontarget species on 2.8-ha control and strychnine-baited sites prior to treatment and for a year after treatment, two nontarget species, Townsend chipmunk (*Eutamias townsendii*) and golden mantle ground squirrels (*Spermophilus lateralis*), were the most frequently captured animals. The data suggest that although individual nontarget animals may encounter and succumb to strychnine bait, these incidents probably do not have long-term impacts on rodent populations. Because other chipmunk species, as well as shrews, and mice were captured infrequently, it was difficult to compare possible changes in their populations.

Habitat Manipulation To Reduce Mountain Beaver Damage to Tree Seedlings—One potential approach to reduce damage to forest resources by mountain beavers is habitat manipulation. To assess the impact of this approach on mountain beavers' consumption of Douglas-fir seedlings, NWRC scientists

from the Olympia field station looked at different habitat regimes: (1) barren; (2) moderate, with inclusion of cat's ear and huckleberry; and (3) complex, with the inclusion of cat's ear, huckleberry, swordfern, salal, and Oregon grape. Prior vegetation foraging trials had indicated that mountain beavers find all these plants desirable to eat.

When animals were confined to a single habitat regime, the most intense damage occurred on the barren sites. Damage was more evenly spread across habitat type when animal densities were kept constant and animals were permitted to roam among habitat regimes.

These results indicate that habitat conditions can influence the extent of damage to tree seedlings. Perhaps the most significant factor in whether a plant is eaten by a foraging animal is the availability of alternate choices. The more desirable the surrounding forage, the less likely a foraging animal will select a tree seedling. Factors that influence diet selection, however, also influence whether animals move to a specific location. Improving habitat conditions can reduce damage to seedlings, provided that populations of the offending animal species are held constant. However, eliminating habitat (for example, by using herbicides) may reduce the presence of problem animal species but increase the extent of damage inflicted by individuals of the species that remain in the area.

Efficacy of Selected Repellants To Deter Browsing by Deer—NWRC scientists continue to evaluate potential repellants to protect forest resources. Information from these evaluations benefits forest managers who need to know the feasibility of repelling wildlife from reforestation units. In 1996, scientists at the NWRC Olympia field station tested the efficacy of four commercial and experimental repellants—Big Game Repellent™-Powder (BGR-P), Deer Stopper,™ Plantskyd,™ and ECX95BY—to deter deer from browsing ponderosa pine, western redcedar and Douglas-fir seedlings. BGR-P was included in the experiment because its potential to protect seedlings from browsing by deer had been



previously demonstrated, and this product was generally known among forest managers. All products were tested under two experimental regimes. One experiment was implemented during the winter, when trees are dormant but often browsed by deer because alternative forage is scarce. The other experiment overlapped budburst in the spring, when seedlings are more desirable and often more difficult to protect from foraging animals.

Less damage to trees occurred during the winter than during the spring. Cedar sustained the most severe damage, while Douglas-fir seedlings sustained the least. Overall, BGR-P performed much as it had in prior trials. In both experiments, it virtually eliminated damage for 2 weeks after treatment and substantially reduced damage in the first 8 weeks. Deer Stopper and Plantskyd compared favorably to BGR-P; ECX95BY, which contained a bittering agent, was less successful in protecting seedlings from deer browsing under these test conditions.

Title: Control of rodent damage to Hawaiian agricultural crops

Goal: Develop safer and more effective methods for reducing rat damage to Hawaiian agricultural crops.

Nonlethal Predator Odors for Reducing Rat Damage to Agricultural Crops—Chemical repellants derived from predators may offer more effective and longer lasting protection from vertebrate depredations than measures currently in use. Rats cause significant economic, health, and ecological problems in Hawaii, and few methods offer satisfactory relief. In the 1870's, Hawaiian sugarcane growers introduced mongooses (*Herpestes auropunctatus*) into Hawaii in an unsuccessful attempt to reduce rat populations in sugarcane fields. Predation by mongooses has not resulted in reduced rat populations, but in many areas mongooses subsist on a diet composed largely of rats.

An earlier study found that rats avoided traps soiled by mongooses, an observation suggesting that rats may have an innate or learned avoidance response to mongooses. For that reason, scientists at the NWRC Hilo, HI, field station conducted laboratory and field studies to evaluate the repellancy of mongoose feces and urine to black rats (*Rattus rattus*) and Polynesian rats (*R. exulans*).

In the laboratory, the scientists exposed captive wild rats to water, butyric acid, mongoose feces, or mongoose urine in a 150- × 60- × 120-cm partitioned arena and recorded their behavior with a video camera. Neither the mongoose feces nor urine had any apparent effect on the rat's behavior.

During the field test, the scientists set 50 pairs of live traps along each of 12 transects in forested areas and adjacent to recently harvested sugarcane fields. One trap in each pair was randomly selected for application of mongoose feces or urine. Significantly fewer rats were captured in traps soiled with mongoose feces than traps soiled with mongoose urine or in unsoiled traps.

The discrepancy between the laboratory and field results in this study indicates that researchers should incorporate relevant factors in the natural environment into their test paradigm and interpret the results of tests with captive animals cautiously. The results from the field study indicate that additional research is warranted to determine the active compound(s) in mongoose feces that repel rats and to explore the use of such compounds to reduce rat damage to agricultural crops.

Economic Thresholds for Controlling Rat Damage to Macadamia Nuts—Rats damage 5 to 10 percent of the developing macadamia nut crop each year, but the impact on yields has not been well documented. Scientists at the NWRC Hilo field station evaluated the effects of simulated damage on yields of mature nuts at two locations on the island of Hawaii. Damage was simulated by removing 10 percent or 30 percent of the developing nut clusters from trees at 90, 120, or 150 days after flowering. At harvest (210 to 215 days after flowering), the number, weight, and maturity of harvested nuts were determined. Removal of 10 percent of the crop load had no measurable effect on yields of mature nuts, regardless of when damage was inflicted. Yields of trees with 30 percent of nut clusters removed differed from yields of control trees (no nut clusters removed) only when damage was inflicted at 150 days after flowering.

These results raise questions about the cost effectiveness of current rodent-control programs, especially during early nut development. Growers may be able to tolerate damage to 10 percent of their developing nuts without suffering economic losses; also, growers may be able to sustain losses as high as 30 percent provided that damage is incurred before 150 days after flowering. Damage efforts should focus on the latter stages of nut development. However, high rat populations and damage prior to this time, although having minimal impact on yields, might indicate the need to apply measures to reduce damage later in the crop cycle.

Improving Methods for Applying Rodenticides in Macadamia Orchards—Macadamia growers in Hawaii try to control troublesome rat populations in their orchards mainly by broadcasting rodenticides on the orchard floor. However, recent studies by scientists at the NWRC Hilo field station indicate that rats in macadamia orchards spend little time on the ground. If rats spend little time on the ground, ground applications of rodenticides may not be effective. To determine the optimum location for placing rodenticide baits in orchards, NWRC scientists evaluated consumption by rats of nontoxic oats that had been placed in various locations in orchards. The oats had been treated with tetracycline hydrochloride, an antibiotic that chelates with calcium in growing bones and teeth and fluoresces under ultraviolet light. About 1 week after the bait had been placed in the orchards, rats were captured and examined for evidence of feeding. The greatest percentage of marked rats was consistently captured in orchards where the bait had been placed in trees, and the lowest percentage was captured in orchards where the bait had been broadcast on the ground. Bait acceptance was intermediate where the bait had been placed in burrows.

These results call into question the effectiveness of rat-control programs that broadcast rodenticide baits on the orchard floor. Placing bait in trees targets rats that not only are more likely to eat the poison but also are more likely to damage developing nuts.

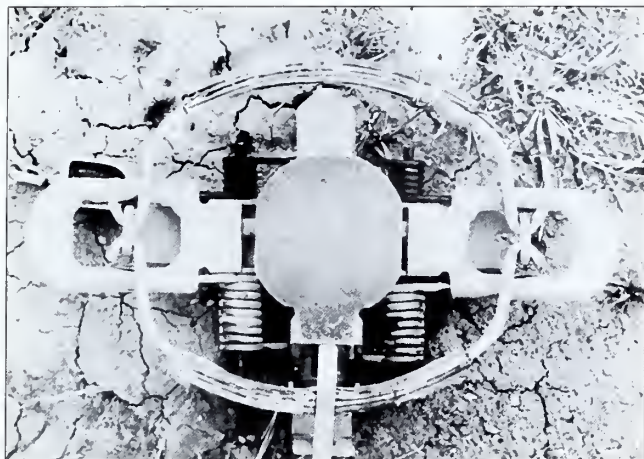
Product Development Research Projects

Title: Development and registration of an oral tranquilizer trap device (TTD)

Goal: Develop and receive U.S. Food and Drug Administration (FDA) authorization for use of an oral TTD for capturing coyotes, wolves, foxes, and other predators.

Tranquilizer Devices on Predator Traps—

Propiopromazine hydrochloride (PPZH) tranquilizes captured animals and reduces anxiety, struggling, and injuries. APHIS has obtained an FDA Investigational New Animal Drug file authorizing the use of PPZH as an oral tranquilizer for capturing coyotes and wolves in foothold traps. Data were collected from 111 wolves (20 pups and 91 adults) and 114 non-target animals from 9 species captured in operational trapping during the 1996 wolf-depredation control season in Minnesota. Laboratory evaluations, including examination of radiographs and necropsy of foot and leg injuries, indicated 37 adult wolves captured in drag traps equipped with capsules containing 500- or 1,000-mg doses of propiopromazine hydrochloride had significantly reduced injuries compared to those captured in traps without capsules (23) or equipped with placebo capsules (15) that contained no drug. Of the adult wolves captured in tranquilizer-equipped traps, 90 percent had injuries in the 3 lowest assessment categories. In contrast, 57 percent of adults captured in traps with no tranquilizer were in higher injury categories with cuts larger than 1 inch, swollen joints, and/or bone fractures above the toes. None of the 42 non-target animals captured in traps equipped with the PPZH capsules succumbed to drug overdoses, and injuries were significantly less severe in traps equipped with the tranquilizer.



The development of more efficient and economical delivery devices and attachment methods for use on traps continues to be a high priority for the ADC program. Properly attaching the device to a trap is of prime importance to prevent a captured animal from dislodging it without ingesting the drug. Likewise, devices must be strong enough to withstand the biting forces of the captured animals but still deliver an effective tranquilizing dose.

Title: Development and registration of new rodent-control chemicals

Goal: Develop safe, effective chemical methods to reduce rodent damage to agricultural crops and rangeland and to provide for public health and safety.

Evaluation of a Hypochlorite Salt Fumigant for Controlling Northern Pocket Gophers—NWRC scientists evaluated hypochlorite salt as a fumigant for controlling northern pocket gophers (*Thomomys talpoides*). The hypochlorite salt had previously shown promise as a fumigant for controlling valley pocket gophers in limited field efficacy trials in California. To secure a Federal registration for this compound, EPA required additional field efficacy data gathered under Good Laboratory Practices. Four treatment areas were established in an irrigated grain-alfalfa hay field in Colorado. At active northern pocket gopher sites, 15 circular sample plots (1/50 acre) were

established in each treatment area. Pocket gopher activity was measured before and after fumigation treatment by the open-hole index. All sample plots on the three units that were fumigated were active, whereas 93 percent of the sample plots on the single control unit were active. Under the conditions tested, the hypochlorite salt was ineffective in controlling northern pocket gophers.

Dupont Oil Blue A: a Biomarking Field Study With Northern Pocket Gophers—NWRC scientists continue to test the hypothesis that the availability of alternative food sources to northern pocket gophers during the alfalfa growing season may be a major factor in reducing the gopher's acceptance of bait. To determine consumption of an oat-groat bait by pocket gophers, scientists prepared the bait with a biomarker and applied the bait underground in an alfalfa field after the last alfalfa cutting. Five days after baiting, scientists reopened the bait sites and examined the bait. Pocket gophers had consumed or transported all or most of the bait at 95 percent of the 59 bait sites. Scientists then trapped the pocket gophers and examined their fat for the presence of the biomarker dye. Of 24 pocket gophers trapped, 21 had ingested the bait and had their subcutaneous fat dyed blue. In males, the blue dye occurred in the fat surrounding the testes; in females, the blue dye occurred in abdominal fat and at the base of the tail. Only three pocket gophers showed no presence of the blue dye. The high bait acceptance in this study may have been due to a seasonal preference for the oat groat following the last cutting when the normally green alfalfa vegetation was absent. This result is in contrast to a previous bait-acceptance study conducted during the alfalfa growing season in which only 35 percent of trapped pocket gophers ingested the biomarker.

Cholecalciferol Laboratory Efficacy Study With Valley Pocket Gophers—NWRC scientists are continuing to evaluate new materials as rodenticides in a laboratory study to determine whether cholecalciferol would be effective in controlling valley pocket gophers. The study was a 3-day, no-choice feeding trial in which 100 valley pocket gophers were ranked

by weight into 20 weight classes and then randomly assigned to 5 treatment groups. Valley pocket gophers captured in California and shipped to NWRC were randomly assigned to a control or to one of four groups exposed to cholecalciferol treated oat groats in varying concentrations: 0.05 percent, 0.075 percent, 0.112 percent, or 0.169 percent. Total mean bait consumption was about 18 g for the control animals and 2.5 g for the cholecalciferol-exposed animals. Mortality was 100 percent in the 0.05 percent, 0.075 percent, and 0.112 percent cholecalciferol group by days 8, 7, and 10, respectively, and 95 percent in the 0.169 percent group by day 7. All cholecalciferol concentrations tested were highly successful in a laboratory situation, with an overall 95-percent mortality rate; however, the gophers were not given a choice of diets. Additional field testing of cholecalciferol is warranted, because it has potential for controlling valley pocket gopher populations.



Title: New solutions for wildlife problems through biotechnology

Goal: Develop and field-test economical and effective immunocontraceptive vaccines to control populations of pest mammalian and avian species.

Deer Immunocontraception—NWRC has finished the fourth year of immunocontraception research on white-tailed deer. Deer at The Pennsylvania State University were injected with natural porcine zona pellucida (PZP) in 1992 and have been monitored each year since for hormonal and antibody response to the injected immunocontraceptive vaccine. Reproductive response was assessed by ultrasound early in gestation and by palpation later in gestation, and finally by comparing the actual fawning rates. All three types of reproductive assessment were important in determining whether the reproductive vaccine resulted in resorption of the fetus; the data indicates that there is no resorption effect from the PZP vaccine. The 4-year fawning data have revealed an 88-percent reduction in fawns in the treated group in comparison with the sham-injected controls (which produced the same mean number of fawns per doe as does in the untested portion of the deer herd). Research is continuing on the development of a synthetic form of PZP that will equal or exceed the performance of natural PZP and allow practical economical production of a field-operational immunocontraceptive vaccine for deer.

Title: Development of analytical chemical methodology for wildlife research

Goal: Develop and apply new analytical chemistry techniques and approaches to wildlife research problems.

Rocky Mountain Arsenal—NWRC chemistry personnel have developed state-of-the-art, environmentally sound methodology to analyze wildlife urine and blood for organochlorine pesticide residues. These methods have been used to determine and correlate blood and urine pesticide residue levels to whole-body levels and toxicological endpoints and will continue to be used to permit nonlethal sampling and determination of wildlife pesticide residues on the Rocky Mountain Arsenal Superfund site in Colorado. The data obtained will permit more effective decontaminating on those areas of this site most essential to the conversion of the Rocky Mountain Arsenal to a wildlife refuge.

Zinc Phosphide Residue Test Methods—NWRC personnel also developed methods more sensitive than any previously published to analyze corn and alfalfa for zinc phosphide residues. These new methods were then used to analyze samples designed to ensure the public safety of zinc phosphide used to control rodent pests in agricultural situations. Information on zinc phosphide residues is necessary to maintaining zinc phosphide registration's for use in agriculture.

DRC-1339 Chemistry Research—Chemistry research has increased the understanding of DRC-1339 in baits and the environment. DRC-1339 has been registered with EPA since 1967 and is widely used to control localized bird populations. In watermelon baits, nonenzymatic browning reactions between sugars and DRC-1339 were shown to be responsible for DRC-1339 degradation. The reaction rate was drastically reduced by the addition of bisulfite to the baits, leading to increased stability of DRC-1339 in the baits. Also, a previously unreported soil metabolite of DRC-1339, azo-CPT, was

identified in laboratory metabolism studies using soil from Louisiana rice fields. A better understanding of the degradation mechanism of DRC-1339 will permit more effective applications of this pesticide for managing bird damage.

Title: Development of chemical control methods for brown tree snake (BTS) management

Goal: Provide control techniques that can be used to prevent the dispersal of BTS's from Guam and to reduce their population levels in various island situations.

NWRC completed its second year of funding by the Department of Defense (DoD) Legacy Program to develop chemical methods for BTS management. NWRC scientists worked on Guam as well as in Denver and Fort Collins to evaluate (1) possible attractants and artificial baits, (2) oral and dermal toxicants and potential delivery systems, (3) snake activity patterns, (4) chemical analysis of pesticide residues in snake tissues, and (5) operational trapping strategies.

Chemical Attractants and Repellants—NWRC biologists and a CSU graduate student conducted field and laboratory trials on lures for the BTS. The most significant finding was that carrion odors are highly attractive to this snake. During the dry season, carrion odors were just as effective as live mice in capturing BTS's in live traps; during the rainy season, carrion odors were only 40 percent as effective as live mice. Odors derived from live mice or other mammalian derivatives (e.g., feces, dander, commercial scents, tissue extracts) were 30 percent as effective as live mice lure. When odor was experimentally prevented from emanating from a trap, the visual presence of the live mouse alone was 30 percent as effective as the live mouse lure. When the visual cue was an inanimate object, such as a mouse effigy, the trap success rate was 5 to 15 percent as effective as the live mouse lures. These findings suggest that the use of carrion odors to construct an artificial lure for BTS holds promise.

One question to address is whether the whole odor fraction of carrion is needed or whether some components of the odor fraction could serve as well. A second question to address is what delivery system to use. Use of aerosol gels (analogous to air wicks) holds the most promise. Such gels can be formulated to hold potential lures for long periods of time and also provide a controlled time-release of the lure material.

Oral and Dermal Toxicants—The active ingredients of three insecticides—rotenone, pyrethrins, and propoxur—were evaluated as oral and dermal toxicants for potential chemical control methods for the BTS. These chemicals were tested in various baits for oral-dose efficacy; these and other chemicals also were evaluated in various matrices as dermal toxicants. Results on ingestion of toxicant-containing baits showed that propoxur (20 mg/bait) and pyrethrins (40 mg/bait) were effective oral toxicants. Formulations of rotenone, pyrethrins, and nicotine in vegetable-oil matrices demonstrated potential as dermal toxicants. Rotenone was determined to be dermally lethal to the BTS, killing all snakes at doses of 10 mg/kg and above; nicotine was dermally lethal at a dose of 40 mg/kg. BTS's were found to readily enter and pass through polyvinyl-chloride (PVC) pipe containing toxicants in vegetable-oil matrices. PVC pipe could be a very useful toxicant delivery container.

Snake Activity Patterns—An important component of a toxicant delivery system for snakes is an understanding of the movements of the animals in terms of the possibility of contacting a toxicant. Radiotelemetry was used to determine the nightly movements of BTS's during both the dry (January–March) and rainy (May–June) seasons. Captured snakes were implanted with radio transmitters and released at their original capture locations, and their movements were monitored throughout selected nights over the course of 4 to 5 weeks during each season. An approximate estimate of movements has been determined by calculating the distances from the original release points. During the January–March period, a lone BTS had moved 55 m from its release point within a

week of its release. Thirty to forty days after release, 36 BTS's moved a mean distance of 81 m; 60 to 70 days after release, 22 BTS's moved a mean distance of 91 m; and 150 days later 2 BTS were located a mean of 54 m from the release site. During the May–June period, the mean distance moved for 22 to 30 newly radio-equipped BTS's was 60 m at 1–7 days and 93 m at 30–40 days. Five BTS's averaged 68 m at 60–70 days.

Daytime denning locations were also determined for 59 BTS's during January–March and for 57 during May–June. Most BTS (73 percent and 75 percent, respectively, during the two periods) denned in trees during the day. *Guamia*, *Pandanus*, *Triphasia*, birdnest fern, and *Vitex* were most commonly used for denning. Snakes denning in trees were located a mean of 3.6 m above the ground in the January–March period and 2.7 m above the ground in the May–June period. During the two seasons, 12 percent and 16 percent of the snakes, respectively, denned on or under the ground, and 13 percent and 9 percent, respectively, denned in dead logs above the ground. The similar movements and denning patterns of BTS's during the two seasons indicate that similar baiting strategies might be effective for this species in both seasons.

Analytical Chemistry Methods Development and Pesticide Residues—Chemical methods for quantifying propoxur, pyrethrin, and rotenone residues in whole-body BTS tissues are being developed by the NWRC analytical chemistry project. The propoxur method has been completed and validated at five levels ranging from 0.1 to 250 µg. Analytical chemistry methods for pyrethrins and rotenone are near completion. Mean recoveries at each fortification ranged from 82 to 91 percent.

To assess potential impacts of residue in eventual field use, propoxur residues were determined in snakes dermally dosed with propoxur at 20, 40, or 80 mg/kg. Residues in snakes exposed at the highest level ranged from 19 to 22 µg/g for fatally dosed snakes to 0.6 to 0.8 µg/g for surviving snakes that were euthanized 3 days after dosing. Residues

in the snakes exposed to 40 mg of propoxur ranged from 13 to 19 $\mu\text{g}/\text{kg}$ for fatally dosed snakes compared to less than 0.1 $\mu\text{g}/\text{g}$ for survivors. Residues in the snakes receiving the lowest dose of propoxur were all less than 0.1 $\mu\text{g}/\text{g}$, as all snakes survived this dosage level. Propoxur residues were also determined in snakes which were orally dosed with propoxur at 20 mg/kg. Residues in the three out of four snakes that died following ingestion of the baits ranged from 105 to 160 $\mu\text{g}/\text{g}$ compared to 120 $\mu\text{g}/\text{g}$ for the surviving snake.

Operational Trapping Assessments—NWRC

began a study in March 1995 to quantitatively assess methods currently being used by the ADC operational personnel to control the BTS on Guam. Results to date indicate that trapping, the principal method used in this program, is effective and that perimeter trapping of a plot of land is the most labor-efficient strategy. A 20-m spacing between traps, the distance usually used for operational control programs, has been highly effective; however, trials comparing 30-m and 40-m spacings to the 20-m spacing revealed that these greater spacings might be appropriate in noncargo areas.

Two plots where BTS's had been removed and been excluded through subsequent maintenance trapping were examined for populations of snakes several months after the original trapping effort. Intensive trapping (51 traps/ha) produced only two captures in a 4.2-ha plot in the first 3 days, followed by no captures for 4 weeks. Similarly, 7 weeks of intensive trapping (40 traps/ha) in a 6.5-ha plot produced only four snakes in 3 weeks, followed by no captures in the final 4 weeks. In addition, three plots that previously had been intensively trapped but not sustained by maintenance trapping were used to study reinvasion rates by BTS. Reinvasion again was slow into completely unprotected plots adjacent to contiguous jungle (5 months without control) and within fragmented habitat (8 months without control). Reinvasion after 11 months was minimal into a plot that had been controlled with a trap line along one edge.

Investigators examined records for all BTS located by the detector dogs (Jack Russell terriers) since the inception of the program. Of the snakes discovered by the dogs, 82 percent were discovered in positions where they were at high risk of being exported from Guam (i.e., they were in the immediate vicinity of vessels and cargo-loading areas or were actually in cargo). Had these snakes left Guam, most of them would have ended up in Hawaii or on other Micronesian islands.

Program Support

Reregistration and Registration Status of APHIS/ADC Pesticides and Drugs

Reregistration Data Submissions and Reports—

APHIS maintains registrations for 7 vertebrate pesticide active ingredients and approximately 40 individual pesticides and has 2 Investigational New Animal Drug authorizations for the ADC program. In addition, NWRC's product development research program coordinates 3 consortia with a combined responsibility for more than 90 vertebrate pesticide registrations. NWRC is responsible for developing and managing all data needed to meet APHIS and consortia commitments to EPA and FDA. During 1996, 21 data submissions and 16 annual, semiannual, or quarterly reports were conducted, contracted, and/or prepared for 4 vertebrate pesticide active ingredients and 2 animal drug active ingredients. These submissions represent contracts or studies that have been underway for up to 2 years and represent a combined direct APHIS consortia investment of more than \$300,000. These reports are required by regulatory actions of EPA and FDA.

Reregistration Status—APHIS is entering the final stages of the EPA reregistration process for its vertebrate pesticides. Owing to NWRC's efforts, four active ingredients (carbon, sodium nitrate, sodium cyanide, and Compound 1080) have been reregistered, and data requirements for a fifth active ingredient (DRC-1339) have been favorably resolved. Reregistration decisions are expected to be made in the next 2 years on strychnine and zinc phosphide. During fiscal year 1996, all data submissions for strychnine were completed, and the EPA Reregistration Eligibility Decision was formulated. Strychnine is expected to enter the final phase of reregistration in 1997. EPA data requirements for the zinc phosphide active ingredient have also been completed; however, reregistration is not expected until late in 1997. A recent review by EPA of information submitted by the zinc phosphide consortium in 1993 on food uses stated that residue data will be required to reinstate the use of zinc phosphide on sugar beets, and processing studies will be required for sugarcane unless no detectable residues are found in field trials

conducted at maximum concentration factors. Reregistration of strychnine and zinc phosphide will finish this round of review for all APHIS, ADC, vertebrate pesticides with no loss of active ingredients or end-use products.

In the original Reregistration Data Call-Ins, EPA requested a total of 433 studies for APHIS' 7 active ingredients—tests estimated to cost \$13.6 million. NWRC provided an enormous amount of technical information to EPA that has resulted in numerous data waivers. Data requirements were reduced through negotiations with the EPA to only 258 studies at a cost of about \$3 million.

Significant Registration Activities—NWRC's product development research program has been active in providing required data and technical support to allow APHIS to make label changes to existing vertebrate pesticides. Requested changes to DRC-1339 staging-area labels that would reduce the fallow time required following application to crop or pasture lands have been prepared. EPA recently responded that this use of DRC-1339 constitutes a food use. As such, EPA will require completion of a rotational field crop study (EPA guidelines 165-1 and 165-2) before reconsidering APHIS' request to reduce the fallow period from 1 year to 30 days. Suggested changes in the DRC-1339 gull label to expand use over the continental United States were also prepared and sent to EPA in 1996. The gull label expansion has been favorably reviewed by EPA; however, until written notice is received by APHIS, the product cannot be used for inland gull populations.

In addition to seeking these use changes, NWRC personnel assisted the ADC Pocatello Supply Depot in implementing formulation changes for a number of the Depot's rodenticide products (required because of the installation of new and improved formulation equipment), and in getting a new gas cartridge approved by EPA and into production.

Significant Drug Activities—During 1996, NWRC personnel assisted with the final planning phase for ADC program use of the TTD with PPZH on coyotes



and wolves, in particular to develop a training and use guide for TTD's. NWRC also completed two Investigational New Animal Drug applications for submission to FDA to allow use of immunoconceptive vaccines. FDA has issued No. 9,958 for Zonacon™ (a zona pellucida vaccine) for controlling deer populations and No. 10,005 for a gonadotropin-releasing hormone (GnRH) vaccine.

New Pesticides and Uses—During the past year, NWRC personnel have begun to assess the potential for obtaining EPA approval for registration of Mesurol as a bird repellent. Mesurol was registered as a bird repellent from 1974 through 1988, but the registration was dropped by its producer because of high projected reregistration costs (several million dollars). Changes in EPA's data requirements may now make it feasible again to register Mesurol. Mesurol has

been purchased by Gowan, a small specialty pesticide producer that is very interested in its repellent uses. NWRC personnel are cooperating with Gowan by (1) collecting and indexing all previous NWRC-generated data, (2) reviewing all the regulatory data that Gowan received from the original producer for adequacy and quality, and (3) establishing cost estimates for data collection to register various uses of this repellent. APHIS, the ADC program, and NWRC will determine the degree of their further involvement in this effort in FY97.

During 1996, EPA published a notice exempting 40 chemicals and natural products from pesticide registration requirements. As a result, NWRC scientists developed a label allowing ADC distribution and use of Egg Oil as material to inhibit the hatchability of gull and goose eggs. NWRC is soliciting

proposals for other uses of compounds on this exempted list and for additional low-risk materials that could be considered for exemption.

Pesticide and Drug Registration Files—NWRC's product development research program personnel have completed designing, entering, proofing, and validating data input into a data base that allows APHIS and NWRC personnel to access the status of individual data requirements for all APHIS or consortia vertebrate pesticides. This cross-referenced data base will be made accessible online once the Center is hooked up to a local area network. Similar efforts have been expended to obtain, input, and validate information on 22 other pesticides and drugs of interest to APHIS' ADC program. Individual citations, along with descriptor terms, have been partially completed for four pesticides and will be completed for most of the remaining pesticides in 1997. These data will also be accessible online and are in an NWRC data base.

DRC Number Data Base Being Assembled—NWRC has undertaken a major 2-year effort to input data on all 7,500 chemicals and other materials that were screened as toxicants and repellants by NWRC between 1960 and 1987 into a searchable data base. This effort, which included development of the data base, is well underway and is expected to be completed in the spring of 1997. The data base will cross-reference DRC numbers with chemical names and will indicate the type, quantity, and location of data developed by NWRC.

Data Provided to State Regulatory Agencies and Cooperators—Product development research program personnel have been interacting extensively with the California Department of Pesticide Regulation (CAL-EPA) to allow the use of ADC pesticides to continue in that State. CAL-EPA has data requirements similar to, and in some cases more stringent than, those of EPA. The NWRC is responsible for submitting all data previously provided to EPA to CAL-EPA, including preparing waiver requests for meeting State regulatory requirements. Other States are beginning to follow in CAL-EPA's lead and are also requiring data, which NWRC is providing.

ADC program cooperators often need access to, or summaries of, data produced by NWRC to include in environmental assessments, environmental impact statements, and in Section 7 consultations with the U.S. Department of the Interior's U.S. Fish and Wildlife Service (FWS). NWRC's product development research program is the prime supplier of this information. More than 100 significant requests were handled in FY 1996, most of which were partially or completely customized for the cooperator.

Information and Technology Transfer

NWRC Library—Information services at NWRC underwent both a formal, external panel review and a strategic planning session in 1996. During the review, panel members and library staff identified all NWRC customer groups and the library services available. NWRC library functions were then analyzed and rated as to their importance and contribution to customer satisfaction. The physical library collection, including books, reports, pamphlets, and videos, was described, and accessibility was discussed. The group discussed trends in library services and management and how NWRC could benefit from new technologies. The Information Services operating budgets for fiscal years 1989 through 1996 were divided into major expenditure categories, and trends in spending were evaluated. The group also reviewed each staff position and the amount of time spent on various tasks. The library staff prepared a user survey which was sent to all ADC offices and NWRC personnel to learn from users or would-be-users what services were considered most important. Information on computer capabilities in the various NWRC and ADC offices was also collected. Results of the user survey were tabulated and used during the review to establish what services the NWRC library would offer in the future. An Information Services mission statement, goals, and objectives was written, and a strategic plan outlining future needs and changes was drafted. The final plan will be completed in 1997.

NWRC's library took the lead in promoting use of the Internet at the Center. Work on an NWRC homepage was begun to establish the Center's presence on the World Wide Web. Information on the NWRC Web page includes a description of the Center and its research activities, a forum for updating current activities, a guide to all of the NWRC field stations, and a description of the library and archives services available. The serial holdings list, various publications (including the 1995 version of this highlights report and the 1995 Annual Publications List), downloadable images of wildlife damage, a staff directory, and a listing of current research priorities

and projects can also be found on the homepage. The NWRC Web pages should be available via the APHIS Webserver in early 1997.

Projects to enhance the NWRC library's collection were continued, and more than 1,800 books were barcoded. All books centralized in the NWRC library are now barcoded and inventoried. All USDA Farmers Bulletins owned by the NWRC library were processed and added to the collection. More than 100 reprints of articles written by Center employees were added to the publication room.

A Pro-Cite™ training guide tailored to the needs of ADC personnel and a list of common standardized descriptors for use with Pro-Cite data bases were compiled. Pro-Cite is a bibliographic software program used by NWRC to organize reprint collections. A library information packet was mailed to all ADC offices. The information packet included a copy of the Vertebrate Pest Conference: Bibliography and Index to the Proceedings 1st–16th (1962–1994), an introduction to library personnel, a list of the aforementioned Pro-Cite descriptors, and a copy of a recent library newsletter.

NWRC personnel continued their important role of disseminating information to a large number of individuals within the ADC program as well as to other clients, customers, and the general public. The NWRC library conducted more than 350 literature searches and provided information on such diverse subjects as BTS control, repellent properties of evergreen oils, aging of pocket gophers, wildlife and sewage treatment plants, strychnine poisoning of humans, white-tailed deer damage to winter wheat, reclamation of abandoned airport runways, trap comparisons, feeding habits of scaup, pair-bonding in gulls, semelparous plants, sarcoptic mange, predation on sea turtles, and use of manmade moats for protection of vulnerable species from predators. The library mailed more than 8,000 NWRC author reprints to requestors. The 1995 Annual Publications List of 138 citations was compiled and distributed. The library requested more than 1,800 books and photocopies from other institutions and, in return, sent

International Visitors

more than 660 items to outside requestors. In addition, more than 1,400 photocopies from NWRC Library holdings were sent to NWRC and other ADC staff in response to individual requests. Increased use was made of the CARL Corporation's Uncover™ data base for document delivery and electronic tables of contents.

NWRC Archives—NWRC's archives unit received large quantities of materials from offices being cleared prior to moving to Fort Collins. This trend will continue and will result in considerable valuable information being archived. Archive staff worked with the quality assurance unit to complete work on specifications for a new quality assurance data base. The challenge was to meet all Good Laboratory Practices (GLP) requirements as well as provide the quality assurance unit with the statistics and information it needs for its daily operation. Archive personnel evaluated a commercially available data base but found it did not meet the Center's needs. APHIS' Information Technology Services personnel are designing a custom data base that will satisfy all requirements. Thirty-nine studies were accessioned into the archive, of which 10 were GLP, 28 were non-GLP, and 1 was a pilot study. Six chemical methods and three chemical notebooks were also archived.

In FY 1996, NWRC welcomed as visitors a variety of scientists and wildlife professionals from the following countries: Belgium, Canada, Colombia, Denmark, England, France, Greenland, Netherlands, Norway, New Zealand, and Switzerland.

German Bird Strike Control

A contingent of six German scientists and Lufthansa German Airlines personnel, including the chairperson of Bird Strike Committee Germany, met with an NWRC scientist, an ADC State Director, and the manager of JFKIA in New York in June 1996. The meeting was requested by the Germans to discuss ADC's gull management program at JFK, which has resulted in a 75- to 90-percent reduction in strikes over the past 5 years. The Germans are determining whether similar programs could be implemented at selected German airports or at other locations where Lufthansa flies.

Chinese Scientist's Sabbatical at NWRC

Zhibin Zhang, rodent ecologist for the Chinese Academy of Sciences, Institute of Zoology, participated in a 6-month sabbatical at NWRC's Olympia, WA, field station. During his visit, Zhang participated in studies to (1) develop methods for assessing rodent activity in artificial burrows; (2) to determine population dynamics and dispersal of pocket gophers, chipmunks, and ground squirrels; (3) to assess methods of managing gophers, chipmunks, and ground squirrels; and (4) to assess methods of managing bear damage to trees in reforestation areas. In the course of this work, Zhang received training in the use of radio-telemetry for wildlife studies and in the use of capture and recapture techniques for estimating rodent populations. Zhang had considerable opportunities during his sabbatical to visit with NWRC scientists, to tour reforestation areas, and to learn about U.S. research approaches to wildlife damage management. He expects his experience in the United States to be valuable in devising research programs for managing wildlife of economic importance in China.

Outreach Activities

Awards and Recognition

Award for Research Excellence—Richard Dolbeer received the Award for Research Excellence presented at the annual meeting of the Northeastern Association of Wildlife Biologists in Farmington, CT, in April 1996. He earned the award for his innovative work in developing and evaluating feeding repellants (in particular dolomitic hydrated lime) for waterfowl.

USDA Unsung Heroes Award—ADC employees Kathleen Fagerstone, Edward Schafer, Jr., and Steve Palmateer received the USDA Unsung Heroes Award. This award is sponsored by the USDA Public Service Employees Roundtable and recognizes the valuable contributions made by USDA employees to the American public. These ADC employees were recognized for their leadership, ingenuity, and resourcefulness in implementing a number of unique processes and innovative funding partnerships to ensure continued registration with EPA of more than 100 compounds related to a number of important vertebrate pesticides used by the ADC program, State agencies, and private companies. The work of the trio is estimated to have saved U.S. taxpayers \$10 million in potential reregistration costs. The recipients managed consortia, arranged for and monitored studies with private laboratories, and prepared data submissions while in the process establishing and maintaining excellent relationships with EPA, State and Federal agencies, and private industry. Without the actions of these employees, there would have been extensive loss of these products to agricultural producers, the wildlife management community, and private industry.

Society of Quality Assurance—Archives technician Laura Greiner was elected to the board of directors of the Rocky Mountain Regional Chapter of the Society of Quality Assurance. She also serves on the Society's newsletter committee.

National Wildlife Telemetry Frequency

Management—During 1996, with funding provided by APHIS, FWS, and the National Park Service, the Interdepartmental Radio Advisory Committee authorized the creation of a national frequency management system to act as the official control for all animal tracking studies. The data base for this operation is maintained at the FWS office in Lakewood, CO, and the authorizations are administered from a list including more than 800 discrete frequencies between 162 and 174 Hz. All Federal telemetry programs involving mammals, birds, reptiles, amphibians, or fish may now obtain frequency authorizations from this national system. One significant advantage of this centralized control is that with the continuing proliferation of animal tracking studies, proper precautions can be taken to minimize the probability of radio interference among projects that may share a common research area. Federal researchers are responding favorably to the convenience and expedience offered by this new system. Non-Federal telemetry users are still managed under the auspices of the Federal Communications Commission.

Meetings, Workshops, and Consultancies

Summaries of some selected presentations show both the diverse nature of NWRC's research and varied interest groups. NWRC scientists make significant efforts to get research information out to the scientific community, customers, clients, and the public in general.

Western Regional Research Coordinating Committee Meeting—Four NWRC research biologists were among 29 individuals who attended the annual meeting of the Western Regional Research Coordinating Committee in Reno, NV, in November 1995. This group of State and Federal researchers, university faculty, cooperative extension personnel, State agricultural department personnel, and private-sector pesticide manufacturers and producers of animal damage management equipment meet each year to discuss ongoing and future research aspects of wildlife damage management. NWRC personnel gave presentations on rangeland rodent problems and management research in Mongolia, predation management research, secondary hazards of rodenticides, research on repellants, and pesticide consortia and registration issues.

Sunflower Research Forum—ADC scientists from NWRC and the North Dakota ADC State office participated in the 1996 Sunflower Research Forum held in Fargo, ND, in January 1996. These individuals made presentations focused on currently used methods of dispersing blackbirds and reducing the damage they cause to sunflower and other grain crops. Particular emphasis was placed on nonlethal approaches to managing blackbird populations, such as managing cattail-dominated wetlands to reduce roosting habitat favored by blackbirds and planting commercially available sunflower hybrids that show resistance to blackbird feeding. Presenters also provided information on how technological advances in reproductive inhibitors may provide a nonlethal population-management tool in the future.

Armed Forces Pest Management Board—NWRC biologists represented the ADC program at the

annual meeting of the DoD Armed Forces Pest Management Board in January 1996 in Gainesville, FL. This meeting reviews USDA research of interest to DoD and provides the basis for DoD recommendations to USDA for future research activities. USDA representatives from the Agricultural Research Service and the Forest Service were also present. NWRC attendees presented an overview of research activities at the Center and the status of the new facility in Fort Collins. Speakers also discussed NWRC research accomplishments and plans regarding wildlife management on airfields, wildlife use of and control at waste-management facilities, and physical density measurements of birds for aircraft windscreen and frame testing. NWRC currently receives funding from DoD and the Federal Aviation Administration (FAA) for research in these areas.

Ontario Horticultural Crops Conference—Richard Dolbeer presented an invited paper at the February 1996 Ontario Horticultural Crops Conference in Toronto, entitled "Blackbird and Raccoon Management in Sweet Corn." The conference was attended by 120 sweet-corn producers interested in reducing red-winged blackbird and raccoon damage. NWRC scientists have developed an integrated management program for blackbird damage control, including the use of bird-resistant cultivars, insect management to reduce field attractiveness to birds, timely use of bird-frightening techniques, provision for alternate feeding sites, and early harvest. Producers communicated a need for evaluation of the various new sonic bird deterrents currently being sold.

Vertebrate Pest Conference—The 17th Vertebrate Pest Conference was held in Rohnert Park, CA, March 3–7, 1996. NWRC Director Richard A. Curnow presented an overview of the Center, and NWRC scientists made 10 technical presentations.

Hershey, PA, Airport Conference—Richard Dolbeer presented a paper entitled "Research To Define and Minimize Wildlife Hazards at Airports" at the 19th annual Airport Conference in Hershey in March 1996. The conference was attended by 650 people in the air-transport industry. Dolbeer's talk covered research

in four areas that NWRC has done for FAA over the past 5 years through an interagency agreement: (1) bird use of landfills in relation to airport operations, (2) habitat management on airports to reduce bird activity, (3) repellent/harassment techniques for airports, and (4) development of a national bird strike data base.

Wing Watch Weekend—NWRC's Ohio field station had a display booth showing research findings and ADC program activities at "Wing Watch Weekend," a program sponsored by the Visitor Bureaus and Audubon Society chapters from four northern Ohio counties on March 16–17, 1996. The theme of the NWRC display was resolving conflicts between people and wildlife. The display explained the concept that wildlife damage control must be an integral part of conservation programs designed to protect and enhance bird populations. More than 500 people attended the program, and the NWRC display generated much positive interest and many questions.

Forest Animal Damage Management Workshop—NWRC's Pullman, WA, field station participated in the third annual Forest Animal Damage-Management Workshop at Washington State University, in April 1996, in conjunction with the university's Forestry Extension Program. The workshop was attended by 20 individuals from Federal, State, and Provincial agencies, 1 Native American tribe, and 3 private forestry companies. Topics included in the 3-day workshop were identification, prevention, and management of damage by various species of mammals, including rodents, hares, ungulates, and bears. Both laboratory and field exercises to demonstrate damage situations and management methods were interspersed with the classroom sessions.

North Dakota Blackbird Damage Talk—In April 1996, George Linz presented a seminar to the Arlington Community Club, Arlington, SD, entitled "Guess Who's Coming to Dinner." Arlington is located in the southeastern corner of the prairie pothole region on a major blackbird migration flyway. In the 1980's, NWRC scientists used aerially applied

markers to determine that many blackbirds moving through the Arlington area were likely to breed in the sunflower-growing areas of the Dakotas. For the past 3 years, scientists from NWRC's North Dakota field station and North Dakota State University have been testing the efficacy and nontarget hazards of DRC-1339-treated rice baits to reduce blackbird populations. About 30 local residents attended the seminar and asked questions on the basic biology of blackbirds and economics of blackbird damage to crops.

Humane Solutions to Problems With Urban Wildlife—In April 1996, NWRC's Ohio field station technician presented a lecture on nuisance avian species (pigeons, starlings, and waterfowl) at a workshop on humane solutions to problems with urban wildlife held in Toledo. The workshop, one of a series being sponsored nationally by the Humane Society of the United States, was attended by 50 people. The NWRC speaker emphasized ADC research that has provided practical, humane solutions to urban wildlife problems: alpha-chloralose to capture waterfowl, bird repellants such as MA, and overhead wires and nest removal for roof-nesting birds.

Electrofishing Training Course—In May 1996, Larry Kolz presented a 3-day workshop in Canada to certify 26 candidates seeking electrofishing positions as crew leaders in the Province of Alberta. This training was done under the auspices of the Lethbridge Community College. Participants were required to demonstrate their handling capabilities with boat, backpack, and float-electroshocking units. Attendees were also required to demonstrate technical competence with electrofishing principles, electrical safety, water safety, and communications skills while performing simulated electroshocking operations.

Wildlife Contraceptives Workshop—In May 1996, NWRC and FDA hosted a workshop titled "Wildlife Contraceptives: The Regulatory Challenge" in Denver. The workshop was attended by 43 representatives from Federal and State agencies, universities, and private organizations. Topics discussed

included the need for wildlife contraceptive products, regulatory responsibility, FDA regulatory process and requirements, and contraceptive technology. Separate breakout sessions were held to discuss issues of regulatory enforcement and licensing, safety and environmental concerns, and effects on wildlife populations. A major accomplishment of the workshop was a definition of the roles of FDA, EPA, and USDA in regulating contraceptive techniques.

Bird Strike Committee Europe—Richard Dolbeer represented NWRC and Bird Strike Committee USA (BCUSA) at the 23d meeting of Bird Strike Committee Europe in London in May 1996. About 120 scientists, military personnel, and representatives of the air-transport industry from 27 nations met to discuss economic, safety, and management issues related to bird collisions with aircraft. Dolbeer presented a paper entitled "Can Albatrosses and Aircraft Coexist on Midway Atoll?" in which he discussed the need to restrict military flight operations to nighttime so as to minimize the bird-strike hazard from more than a million nesting albatrosses. Another paper involving NWRC research on physical densities of birds in relation to aircraft damage was presented by cooperating personnel from the U.S. Air Force. One theme that emerged from several presentations at the conference was the need for new tools for aggressive management of increasing populations of large flocking birds, such as geese and gulls, at airports.

American Society of Mammalogists Annual Meeting—Craig Ramey presented a talk on historical fox rabies data used in the Texas oral rabies vaccination program at the annual meeting of the American Society of Mammalogists, held in June 1996, in Grand Forks, ND. Ramey discussed fox rabies surveillance data from the Texas Department of Health (TDH) that were analyzed by NWRC for temporal and spatial patterns. Since 1922, Texans have been submitting gray foxes (*Urocyon cinereoargenteus*) and red foxes (*Vulpes vulpes*) for rabies testing. Since 1922, more than 2,700 rabid foxes have been identified. Between 1922 and 1945, fox rabies was almost nonexistent in Texas. Since 1945, the data suggest that two epizootics have

occurred there, the first beginning in 1946 and the second beginning in 1988. Data on the historical spread of fox rabies in Texas were used to determine the distribution pattern of vaccine baits used in 1996 by TDH in its oral rabies vaccine program to halt the spread of rabies. This program distributed more than 1.25 million vaccine-laden baits across 53,000 km² (20,500 mi²) in a band along the periphery of the epizootic. In succeeding years, the vaccination zone will be decreased until the epizootic has been controlled.

Bird Strike Committee USA (BCUSA)—About 180 people attended the sixth annual BSCUSA meeting at the Phoenix, AZ, Sky Harbor International Airport in July 1996. The meeting was organized by ADC and NWRC biologists from New York and Ohio in cooperation with the American Association of Airport Executives. Speakers presented 32 technical papers on topics related to economic and safety problems caused by wildlife, especially birds, colliding with aircraft. In addition, Mike Dunn, Assistant Secretary of Agriculture for Marketing and Regulatory Programs, gave a presentation related to the important role ADC research can play in resolving bird-aircraft strikes. Five companies exhibited their wildlife management products, and a training session was held on bird identification and wildlife management at airports. Attendees included representatives from the air-transport, solid-waste-management, and pest-management industries, airports, natural resource agencies, FAA, the National Transportation Safety Board, and the military. The goal of BSCUSA is to increase communication and professionalism among the diverse groups dealing with wildlife issues at airports.

National Society of Quality Assurance—Clay Mitchell and Sella Smillie presented invited papers at the National Society of Quality Assurance training session in Kansas City, MO, in July 1996. They spoke on a system for protocol writing and preparation and archiving and recordkeeping for GLP studies. This was the only training session held this year by the National Society of Quality Assurance and was attended by more than 60 quality-assurance professionals from the private sector.

Experimental Aircraft Association Convention—A biologist from NWRC's Ohio field station worked at the ADC information booth at the Experimental Aircraft Association Convention in Oshkosh, WI, in August 1996. This annual air show is the largest gathering of pilots in the world, attracting more than 800,000 visitors. Through an interagency agreement with FAA, the NWRC Ohio field station maintains a national data base of reports of bird and other wildlife strikes with aircraft. There are more than 15,000 strike reports for civil aircraft in the data base for 1989–96. Analysis of these reports indicates wildlife strikes cost the U.S. civil aviation industry well over \$100 million per year, but that figure is based on less than 25 percent of all aircraft–wildlife strikes having been reported. It is critical to have a current and complete national data base that defines the extent and nature of the wildlife–aircraft problems so that research and management programs to reduce strikes can be properly focused and justified.

Air Safety Forum—A scientist from NWRC's Ohio field station reviewed ADC research and participated in a panel discussion on wildlife hazards to aviation at the Air Safety Forum in Washington, DC, in August 1996. About 300 pilots attended the forum, which was sponsored by the Air Line Pilots Association. Other participants on the panel included a member of the National Transportation Safety Board and the director of the FAA Office of Airport Safety and Standards. Forum attendees expressed strong support for ADC's efforts in reducing wildlife hazards at airports. As an outgrowth of this meeting, the Air Line Pilots Association is establishing a wildlife-hazards working group to focus more attention on the development of effective methods, programs, and procedures for reducing hazards.

Mississippi ADC Meeting—In August 1996, biologists from NWRC's Mississippi field station attended the annual State meeting of the Mississippi ADC program. There they gave presentations on radio-telemetry methods for studying bird movements and on NWRC research to develop chemical methods for controlling BTS populations on Guam.

ADC Airport Training Workshop—Two biologists from the Sandusky, OH, field station represented NWRC at the ADC Airport Training Workshop held at the FAA Technical Center, Atlantic City International Airport, NJ, in September 1996. The NWRC biologists were part of the teaching team that provided training to 30 ADC personnel who are undertaking various projects at airports to assess and reduce wildlife hazards. ADC biologists who attended the workshop and passed an exam were certified to work at airports. In addition, an ADC airport manual is being developed to provide standardized procedures for cooperative agreements to conduct hazard assessments and control work at military and civilian airports. Wildlife strikes cost civil and military aviation more than \$200 million a year in the United States.

Course on Rodent Pest Management and Control for the U.S. Agency for International Development (USAID) Africa—In late September 1996, NWRC scientist Gary Witmer served as an instructor for the USAID regional training course on rodent pest management and control, in Nairobi, Kenya. Twenty trainees from nine East African countries attended the 6-day workshop. A substantial number of rodent species cause regular, and occasionally severe, damage to crops both in field and storage situations in Africa. Witmer gave lectures and demonstrations of the principles of vertebrate pest management, rodent and crop damage assessments, rodenticides and toxicology, and the use of radiotelemetry. Site visits included subsistence farms and grain storage facilities, the National Museum of Kenya, and Kenyatta University. Researchers from each of these two Kenyan institutions also assisted in instruction. The workshop was well received by the trainees and by USAID personnel in attendance.

Chicago Airport Conference—Richard Dolbeer presented a paper on habitat management at airports to reduce wildlife hazards at the 11th annual Chicago Airport Conference in November 1995. He explained methods for modifying landscaping, turf, woodlands, fencing, water resources, and structures to reduce wildlife hazards to aircraft to an audience of

40 midwestern airport managers and operations personnel. Because each airport has unique characteristics, managers at each airport will need to determine the best turf-management strategy to alleviate wildlife hazards.

Second World Congress of Environmental Toxicology and Chemistry—Lowell Miller participated in the second World Congress of Environmental Toxicology and Chemistry in Vancouver, BC, in November 1996. A poster presentation on the responses of bucks to white-tailed does treated with immunocontraceptives during the rut was written by other NWRC personnel and Pennsylvania State University scientists Gary Killian, Eric Wilhelm, and Mike Hummel. The presentation explained the behavioral effects of prerut PZP vaccine treatments for immunocontraception related to repeated estrous cycling in deer.

Meeting of the Ohio Coordinating Committee for the Control of Depredating Birds—The staff of the NWRC's Ohio field station presented findings from 1995 to the annual meeting of the Ohio Coordinating Committee for the Control of Depredating Birds in Columbus, OH, in December 1995. The committee, with representatives from agriculture, the pest-control industry, State and Federal agencies, and universities, has met annually since 1965 to discuss vertebrate pest problems in Ohio and to provide direction for research and management efforts. The major area of discussion at the 1995 annual meeting was overall increases in wildlife damage in the State as reported by Ohio Farm Bureau members for deer, raccoons, coyotes, geese, and turkeys. One notable research finding presented was that the red-winged blackbird population in Ohio has declined by 67 percent since 1970. This decline, caused in part by agricultural changes such as increased corn and soybean production and reduced hay field acreage, lessened Ohio farmers' complaints about blackbird damage to ripening corn in 1995.

Cooperation With Agencies and Universities

American White Pelican Banding Program

Reestablished—American white pelicans that winter in the delta region of Mississippi, Louisiana, and the gulf coast breed in the north-central United States and Canada. A better understanding of the population status and migratory movements of these birds could lead to more effective strategies for managing depredations at aquaculture facilities. For that reason, NWRC, in cooperation with FWS, reestablished a pelican-banding program at Chase Lake National Wildlife Refuge in North Dakota. The Chase Lake refuge contains the largest breeding colony of American white pelicans in North America. Personnel from the ADC program, the U.S. National Biological Service, St. Cloud State University, and North Dakota State University assisted with the project. NWRC biologists will continue to monitor breeding and wintering pelican populations and will capture pelicans for satellite and VHF-transmitter tracking studies. These studies will help determine the impact of wintering American white pelicans on the aquaculture industry in the Southeastern United States and provide information necessary for developing control strategies.

U.S. Air Force Bird-Avoidance Model—NWRC has entered into an interagency agreement to work with the Air Force on their bird-avoidance model. It incorporates migration and population data for waterfowl and other birds across the United States and predicts the relative risk of aircraft encountering birds during low-level training missions by time of day and year and by geographic location. NWRC will provide risk assessments for training routes as requested by the Air Force and will work to improve the completeness and accuracy of the model. The work will be conducted by personnel at the Ohio field station.

Bird Tissue Research—Biologists at NWRC are cooperating with the Canadian Wildlife Service (CWS) to investigate the use of naturally occurring stable isotopes of various elements in bird tissues as a means of associating individuals to wetland com-



plexes. NWRC has supplied CWS with more than 600 red-winged blackbirds collected from several locations from Louisiana to the Canadian border. CWS research has shown some promising trends that may ultimately be applicable to pinpointing habitat associations of blackbirds in various flyways. CWS hopes to be able to use the redwing as an indicator species for this research.

Equine Protozoal Myeloencephalitis Research—

Equine protozoal myeloencephalitis is a severe, often fatal, disease of horses that occurs when *Sarcocystis* protozoans infect the spinal cord. The life history of this protozoan is complex, and recently researchers in Kentucky and Florida matched DNA from nervous tissue of affected horses and *Sarcocystis* organisms taken from opossums and birds. The opossum is the definitive host, and various birds (including brown-

headed cowbirds and grackles) are intermediate hosts. In cooperation with University of Florida research personnel, biologists at NWRC's Florida field station have trapped cowbirds and grackles as part of a 2-year study that will determine the frequency of occurrence of the parasite in wild populations and evaluate the growth and persistence of the parasite in infected birds. This research will lead to more complete understanding of patterns of parasite growth and transmission so that more effective measures to combat equine protozoal myeloencephalitis can be developed.

Swift Fox Conservation Team—Russ Mason from the Logan, UT, field station met with the Swift Fox Conservation Team in September 1996 in Denver. Representatives from 10 Western States plus the Department of Interior's Bureau of Land Manage-

Science Education

ment, FWS, National Biological Service, CWS, USDA's Forest Service, and ADC operations met to discuss conservation strategies and research needs to address the petition to list the swift fox as endangered or as threatened. NWRC will be represented on the research technical committee of the swift fox conservation team. This committee will address research needs and funding requirements for increasing knowledge on the swift fox's distribution, abundance, and interactions with other predators within the prairie States and Canadian Provinces.

Texas Oral Rabies Vaccination Program—An NWRC scientist assisted the TDH, the Texas ADC office, and personnel of other Federal, State, and local agencies in initiating an innovative oral rabies vaccination program to control a rabies epizootic in coyotes and gray fox that began in Texas in 1988. The goal is to produce a zone of vaccinated coyotes along the northern leading edge of the South Texas canine rabies epizootic and vaccinated foxes along the periphery of the west Texas gray fox epizootic. These actions are intended to halt the spread of the epizootics by encircling them. The program is using a safe recombinant vaccine that incorporates only noninfectious portions of the rabies virus. Each dose of vaccine is placed in a plastic sachet and inserted into the hollow center of a dog food bait. In the 1995 vaccination program, more than 2.5 million vaccine baits were aurally distributed over 31 days. The initial phase of the Texas program has been highly successful, both in the careful distribution of vaccine baits and the extensive cooperation shown by all parties in mobilizing to address a severe public health issue.

NWRC Summer Interns

NWRC hosted two undergraduate students as interns. Chaudett Gullen, a sophomore at Missouri's Lincoln University majoring in animal science, and Margina Moore, a biology major at Fort Valley [AL] College, gained familiarity with the ADC research program. Their assignments included work with scientists in diverse projects related to the geographic information system, rodent and bird toxicology, studies of repellants, and veterinary animal care.

NWRC Tours

On April 1, 1996, NWRC scientists provided a tour of the Center's Animal Research Building in Fort Collins at the request of five animal rights or animal welfare groups from Colorado. The groups represented Students for the Ethical Treatment of Animals, Women Bearing Witness, Sinapu, Rocky Mountain Animal Defense, and Public Lands Watch. Fourteen individuals were given the opportunity to view and discuss the animal-care conditions in this facility, as well as to learn about the NWRC research program.

University of Nebraska Wildlife Students

Later in April, NWRC staffers hosted about 25 wildlife students from the University of Nebraska Wildlife and Fisheries Department. The students were escorted by Scott Hyngstrom, wildlife extension specialist with the university. Tours of the Center and the Animal Research Building and presentations and discussions of current research activities were provided by Center personnel.

Ohio State Wildlife Students

NWRC's Ohio field station hosted 15 wildlife biology students from Ohio State University for an ADC field day on October 7 and 8, 1996. Students were given hands-on instruction in the scientific method, collection of data on bird-resistant crop varieties, assessment of wildlife damage to crops, and habitat use by

deer. Presentations emphasized emerging conflicts between wildlife and people and the research needed to resolve these conflicts.

Elementary School Wildlife Presentations

Two biologists from NWRC's Ohio field station presented programs on wildlife research and wildlife damage management in October 1996 to about 500 sixth-grade children. These presentations were part of a 2-day program in conservation education sponsored by the Erie Soil and Water Conservation District. This is the 11th year that personnel from the Ohio field station have cooperated with the District in this event and more than 4,500 students have attended these presentations.

Graduate Course on Advanced Wildlife Topics at Washington State University

NWRC scientist Gary Witmer taught a graduate student course on advanced wildlife topics to seven students. Witmer, an NWRC project leader, is based at the Department of Natural Resource Sciences at the university, where he is also an adjunct associate professor. The students researched and discussed current "hot issues" in wildlife management such as exotic species of plants and animals, reintroduction of wolves, overabundant wildlife populations, initiatives to enhance wildlife habitat on public and private lands, human safety issues associated with bears and cougars, initiatives to restrict the hunting of wildlife, and disease transmission between wildlife, humans, and livestock. Because these topics are controversial, students at times disagreed amongst themselves but learned to better articulate and substantiate their viewpoints. Witmer served as a facilitator and mentor in the discussion group.

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[Boldface type indicates NWRC authors.]

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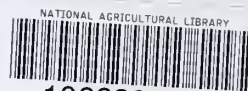
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